PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of

Applicant	:	Schaefer et al.
Serial No.	:	09/996,244
Filed	:	November 28, 2001
Title	:	TRAPPING AND STORAGE OF FREE THERMAL NEUTRONS IN FULLERENE MOLECULES
Docket	:	594826-001C1
Art Unit	:	3641
Examiner	:	Behrend, Harvey E.

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Commissioner for Patents
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Sir:

APPEAL BRIEF

This is an appeal from the Final Rejection mailed December 12, 2003. A Notice of Appeal was submitted on March 12, 2004 with a one month extension of time. This Brief is accompanied by an amendment of claim 4 that is submitted under 37 C.F.R. §1.116.

(1) Real Party in Interest

This application has not been assigned. The applicants are the real party in interest.

(2) Related Party in Interest

There are no other appeals or interferences pending which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

(3) Status of Claims

Claims 1-8, 10-14, 16-19, 29, 30-34 are pending in the application. Claims 30-32 are withdrawn from consideration.

(4) Status of Amendments

An amendment correcting a grammatical error in claim 4 is being submitted herewith under 37 CFR §1.116. The amendment places the claims in better form for appeal and its entry is respectfully solicited.

(5) Summary of the Invention

The present invention is a fullerene molecule having one or more thermal neutrons trapped within its cage-like structure. The invention is based upon the discovery that free thermal neutrons can be trapped within the cage-like structure of a fullerene molecule.

Fullerenes are extremely stable molecules of carbon that take the form of a hollow geodesic sphere containing 32 to several hundred carbon atoms. Fullerenes containing 60 carbons(C_{60}) are better known as Buckminster fullerenes or "buckyballs." C_{60} fullerene has an icosahedral symmetry consisting of 12 five-member rings and 20 six-member rings and resembles the patchwork faces of a soccer ball. (C_{70}) Fullerenes contain 25 six-membered rings and have a shape resembling a rugby ball (page 1, lines 4-13).

In accordance with the invention, *free thermal neutrons* are used to irradiate a sample of a fullerene which traps the thermal neutrons within the cage-like structure of the fullerene. After exposure, the neutrons remain confined with the fullerene molecule until they are released or decay (page 3, lines 1-15). The issues on appeal surround the method for making and for verifying the making of fullerenes containing trapped thermal neutrons. Conceptually, the manufacture of the fullerene is simple. A vial of fullerene is placed in the thermal neutron flux of a nuclear reactor. The Example at page 7 of the application teaches putting the fullerene in the carrier tubes in a nuclear reactor and irradiating at a steady state power of 10 to 50 kw for 5 to 15 minutes and recovering the sample.

Entrapment of the thermal neutron is verified based on gamma spectrographic analysis. By a process known as "half-life stripping" interfering gamma emissions are stripped from the data. When this process is completed, the applicants find that the fullerene exhibits a beta emission with a half-life of 10 minutes. This emission indicates that a thermal neutron is present and the only place this neutron could exist is in the fullerene cage.

In making the §112, first paragraph rejection, the Office questions the integrity of the experimental data and its interpretation. No reason is given for doing so. The Office also questions the criticality and availability of pure fullerene.

(6) Issues

The issues are:

(A) Does the specification provide enabling disclosure for claims 1-8, 10-14, 16-19, 29, 33, and 34? This issue requires resolution of the following subissues:

(i) Does §112 require that applicant's specification provide adequate data to establish that applicants conclusion that they have trapped a thermal neutron in a fullerene molecule is not based on experimental errors or a misinterpretation of results?

(ii) Is the specification defective because it does not contain sufficient data to establish that the neutron is in the center of the fullerene?

(iii) Is the specification defective because it fails to teach how to make or identify high purity fullerenes?

(B) Are claims 4-8, 10-14, 16-19 deficient under 35 U.S.C. §112, second paragraph because they recite a use instead of a property of the claimed fullerene?

(7) Grouping of the Claims

For the purpose of this appeal, as they relate to issue (A) above, the claims are considered to stand or fall together. As they relate to issue (B), each claim stands on its own merit.

(8) Argument

(A) §112, First Paragraph Rejection.

With respect to the rejection under 35 U.S.C. §112, first paragraph, the Office contends that the specification does not describe the invention in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use it.

The applicants submit that the rejection of claims 1-8, 10-14, 16-19, 29, 33 and 34 under the first paragraph of 35 U.S.C. §112 is directly contrary to *In re Cortright*, 165 F. 3d 1353 (Fed. Cir. 1999) where the Federal Circuit cited its precedent in *Newman v. Quigg*, 877 F. 2d 1575, 1581 (Fed. Cir. 1989) and *Fromson v. Advanced Offset Plate, Inc.*, 720 F. 2d 1565, 1579 (Fed. Cir. 1983) and held that an inventor does not need to prove the scientific principles upon which his invention works. In making the rejection under §112, first paragraph, the Office raises issues of experimental error and misinterpretation of experimental results. However, under *Cortright* and its predecessor cases, questions of experimental error and disputes regarding the interpretation of results are not issues under §112, first paragraph. Rather these issues go to the underlying theory for the invention and do not impact enablement. The applicants submit that the issues under the first paragraph are simple; namely, have the applicants taught how to make their invention. The applicants have described a process in which a vial filled with fullerene compound is placed in the thermal neutron flux of a nuclear reactor, irradiated, removed, its β-decay monitored and analyzed, and the presence of thermal neutrons in the sample confirmed. The applicants submit that these teachings meet the enablement requirement of §112 and Dr. Joseph Talnagi, an expert in the field from Ohio State, agrees in the affidavit that is of record.

The Office is maintaining the §112, first paragraph rejection based on unsupported suspicions that the β-emitter the applicants are observing may not be a trapped thermal neutron and, if it is, that neutron may not be in the cage of the fullerene. These unsupported suspicions particularly in the face of Dr. Talnagi's affidavit, do not provide an appropriate basis for rejection under §112, first paragraph. *In re Marzocchi*, 169 U.S.P.Q. 367 (CCPA 1971).

Entrapment of a free thermal neutron in a fullerene molecule is not "incredible." There are reports in the literature of "contained" thermal neutrons. The applicants previously cited the paper by Huffman, et al. Nature, Vol. 403, 6 Jan. 2000, pg.62 as evidence of similar behavior by a free neutron in a macroscopic neutron trap that confines free neutrons within its interior cavity. Huffman's trap uses the neutrons' own magnetic field to accomplish this. The applicants note that the publication date of this paper is several years after the applicant's initial application.

Additionally, it is a demonstrated fact that, below a "threshold energy," free neutrons will "flow" through an evacuated cold tube because they lack the energy to penetrate the wall of the tube. The evacuated tube leads from the core of a reactor to the exterior of the reactor. A bend in the tube is used to isolate the cold neutrons from higher energy neutrons. The higher energy neutrons cannot negotiate the turn and escape the tube while the cold neutrons rebound from the tube's wall and remain inside the tube. The angle of the bend in the tube and the wall temperature maintained in the tube will set the maximum energy of the neutrons remaining in the tube. This is a common process for isolating the "cold" or low energy neutrons from the neutron flux of a reactor. See "The Physics of Ultracold Neutrons by V. K. Ignatovich, ISBN 0-19-851015-2 and "Ultra Cold Neutrons" by R. Golub et al., ISBN 0-7503-0115-5.

Thus, there is nothing new or radical or incredible about the idea that cold neutrons can be isolated. What is new art is the realization by the applicants that, to a neutron, the wall of a fullerene molecule appears just as solid as the wall of a neutron guide tube in a nuclear reactor.

The Office bases the enablement rejection on a number of assertions that go solely to the underlying theory for the invention and that are completely inconsistent with *Cortright*. The Office asserts that there is no reputable evidence that the neutron's magnetic field will keep it in the center of the fullerene, but the claims say nothing about magnetic fields. The Office asserts that there is no evidence that the fullerene electron cloud keeps the neutron in the center of the fullerene, but the claims say nothing about an electron cloud. The Office contends that the disclosure teaches nothing about having enough energy to penetrate one side of the fullerene but

not the other, but the claims say nothing about this. These are mere theories which, under *Cortright* are "icing on the cake" but not required under §112, first paragraph.

The applicants have previously explained their belief that a fullerene molecule traps a neutron inside the fullerene's internal cavity when the neutron has enough energy to penetrate the wall of the fullerene molecule only once. The applicants contend that a neutron loses energy in penetrating the wall of the fullerene molecule and reaches the interior cavity of the fullerene with less energy than it had before it first penetrated the wall of the fullerene molecule. This process traps the neutron when at this new, lower energy state, the neutron lacks the energy to penetrate the wall of the fullerene molecule again and escape. Inside the fullerene molecule, the neutron has no means of gaining the necessary energy to escape so it remains inside the fullerene molecule until it decays.

The applicants have previously explained that individual neutrons in the neutron flux of a nuclear reactor have a broad range of energies dependent on the location of the measurement of the energies of the neutrons. Some very low energy neutrons that reach the fullerene sample within the reactor may be unable to penetrate a fullerene molecule at all. On the other hand, high-energy neutrons would pass right through both walls of the fullerene molecule in the sample as the examiner suggests. The applicants contend that there is a mid-range of neutron energies where a neutron encountering a fullerene molecule has enough energy to penetrate the wall of the fullerene molecule to reach the interior cavity and that in the process the neutron loses enough energy such that it cannot again penetrate the wall of the fullerene molecule to escape. Free neutrons exchange kinetic energy with moderators in nuclear reactors exactly for extracting energy from high-energy neutrons. This is how nuclear reactors produce thermal or low energy neutrons. This process occurs without the nuclei of the moderator capturing the neutron during the energy transfer. This demonstrates that neutrons do loose energy through such interactions. The wall of the fullerene molecule appears to act as a moderator extracting energy from the neutron as it passes into the fullerene's internal cavity. The applicants believe that the gross features of the capture process are no more complicated than this.

The fact that after irradiation by neutrons, fullerene molecules exhibit decay radiation that is indistinguishable from the decay of free neutrons demonstrates the existence of the neutrons as free thermal neutrons inside the fullerene.

In persisting in the rejection, the Office contends that the applicants have not proved that the neutron is inside the fullerene cage as opposed to at some other location. The applicants submit that this is the weakest aspect of the Office's rejection simply because, if we assume for

the sake of argument that the β-emitter is in fact a thermal neutron, there is simply no other place that this neutron could be except in the fullerene cage and still emit a β-particle. Dr. Talnagi attests to this in his affidavit. But for the fullerene cage, the thermal neutron would interact with other nuclei and/or be consumed such that it could not exhibit the characteristic β-emission. Accordingly, in order to behave like a free thermal neutron and exhibit its characteristic β-decay, the neutron must be held in a location in which it is effectively isolated from interaction with other nuclei. The only location that could conceivably provide this type of isolation is the fullerene cage as attested to by Dr. Talnagi. In view of the Talnagi affidavit, the Examiner's unsupported doubts cannot legally support the rejection.

No other known material exhibits the β-emission observed by applicants. Diamond and graphite do not, even though both graphite and diamond are allotropes of pure carbon as are fullerenes. Diamond and graphite lack the interior cavity unique to fullerenes. Neutron activation is one of the lines of research. There is no reference in the literature to any diamond ever exhibiting beta decay radiation with a half-life of 10.25 minutes. The applicants' own experiments on diamond samples in place of fullerene samples confirm this. Some reactors use graphite as a moderator. There is extensive, published characterization of the behavior of graphite as a neutron moderator in nuclear reactors. There is no published data in the literature identifying graphite's ability to contain free neutrons by either trapping the free neutron or reflecting the neutron within the carbon atoms for a period of minutes after the sample exits the neutron source, as postulated by the examiner. The applicants submit that, no reasonable basis remains for the rejection and the rejection must be withdrawn.

Turning lastly to the need for high purity fullerenes, the applicants wish to clarify for the Board that contaminants do not prevent the fullerene molecules in the contaminated sample from trapping free neutrons. Contaminants only interfere with observing of the beta radiation that is characteristic of the trapped neutrons. Samples with unacceptable contaminants produce beta decay radiation with half-lives between 2.25 and 55 minutes and prevent the post irradiation measurement and observation of the decay of the trapped free neutrons.

The applicants trapped thermal neutrons in the fullerene using commercially available fullerene samples. The most frequent source of the applicants fullerene samples is Materials and Electrochemical Research Corporation (MER Corp.), 7960 South Kolb Road, Tucson, Arizona 85706, Phone: 520.574.1980, Fax: 520.574.1983, MERCORP@MERCORP.COM. The applicants buy material with the catalog number MR7SB. MER Corp. was the source of the samples discussed in Table I, below. The fullerenes available from chemical and laboratory supply companies have steadily improved in purity. The applicants recently have tested samples

where the only activated contaminant was ^{41}Argon that would appear to come from the air in the sample container. The applicants used only commercially available fullerenes in the work described in the disclosure.

There are no generally accepted purity standards for fullerenes. Different researchers have different requirements. For example, one researcher may be concerned about the hydrocarbon content of his fullerenes but another is unconcerned about trace amounts of chlorine. The applicants are not concerned about hydrocarbon content because thermal neutrons do not activate hydrocarbons. Conversely, activated chlorine will affect the post irradiation measurement of the beta decay radiation from free neutrons. The applicants expect that, should circumstances warrant, based upon the applicants teachings, persons skilled in the art will adopt standard quality and purity definitions for fullerenes for use in trapping free neutrons to facilitate post irradiation testing.

The applicants acknowledge that the presence of some contaminants, as has been explained, can result in erroneous post-irradiation measurement results. However, the procedures described in the application are designed to detect such potential sources of error. Further, the applicants identified and developed the half-life stripping procedures described in the application, for just this reason. The applicants anticipated and addressed potential erroneous results. The procedures described in the application agree with standard laboratory procedures related to neutron activation and post irradiation data collection and analysis for removing the influence of contaminants during data analysis. Further, these procedures are consistent with procedures that would be expected to be used by a person with ordinary skill in the art of neutron activation to ascertain and address potential sources on sample contamination and eliminate erroneous data. Clearly, if one skilled in the art is trying to detect a β-emission indicative of a thermal neutron, one would naturally use a fullerene that does not contain contaminants that interfere with that analysis.

While the applicants submit that the Examiner's concerns with experimental error are not a proper basis for rejecting the claims, with respect to possible sources of experimental error related to the determination of the presence of the trapped free thermal neutrons, the applicants have addressed potential sources of error successfully and adequately in the application. There have been repetitive sample experiments yielding positive results to demonstrate repeatability. The laboratory maintains equipment in standard maintenance and calibration to insure correct and accurate measurements. The applicants use standard laboratory sample handling procedures to control sample quality. The testing of the irradiated fullerene samples, as described in the application, uses a standard gamma spectrometer, to screen out samples with contaminants that

produce beta radiation with half-lives between 2.25 and 55 minutes. This insures that these contaminants will not preclude the successful measurement of the decay of the trapped free neutrons. Finally, the applicants use of standard beta decay data recording and analysis procedures, as commonly used within the industry and described in reference works to analyze the experimental data.

TABLE I

Sample	Experiment Date	Initial Abundance of Neutrons	Half-Life in Minutes
B	24-Oct-00	5981	7.72
D	27-Nov-00	3647	8.06
F	27-Nov-03	6525	9.18
H	21-May-03	10940	11.58
	Average Half-Life (minutes) =		9.135
	Standard Deviation (minutes) =		1.74527
	Accepted Neutron Half-Life (minutes) =		10.25

With respect to the repeatability of the experimental procedures, the applicants provide the above table. The table contains data from four relatively recent experiments that followed the procedure in the disclosure. Note that in only four tests, the results yield an average beta-decay half-life of 9.135 minutes; this is 1.115 minutes less than the accepted neutron half-life. The accepted neutron half-life is well within the 1.745-minute standard deviation of the data. The nearest contaminant emitter, ^{28}Al at 2.25 minutes half-life, is four times the standard deviation less than the experimental neutron half-life.

With respect to the use of the gamma spectroscopic assessment of the irradiated samples to eliminate any samples containing identified beta decay emitters with half-lives between 2.25 and 55 minutes, this is a standard laboratory procedure to identify the constituents of the irradiated samples and, using published data, identify any beta decay half-lives within the 2.25 to 55 minute window. The use of gamma spectroscopy of the irradiated fullerene samples to quantify the constituents of the irradiated sample, eliminates from further use those samples containing radionuclides with beta decay half-lives between 2.25 and 55 minutes. Together, this provides adequate assurance that the disclosed methods can adequately demonstrate the presence of trapped free neutrons and that expected sources of error can be precluded from such methods by persons normally skilled in the art of neutron irradiation and related measurement methods.

In summary, the applicants request the Board to reverse the §112, first paragraph rejection. The Example in the application clearly teaches how to make the claimed fullerenes by placing them in a thermal neutron flux. Additionally, the application teaches how to verify the claimed compounds by using spectrographic techniques. The purity of the fullerene simplifies detection but does not preclude one from making the claimed materials.

(B) §112, Second Paragraph Rejection.

The applicants traverse the rejection of claims 4-8, 10-14 and 16-19 under the second paragraph of §112. In making the rejection, the Office notes that there is a grammatical error in claim 4. That error is corrected in the accompanying Amendment Pending Appeal that is submitted under 37 CRF §1.116.

Apart from the grammatical error in claim 4, the applicants submit that the language of the claims is clear that the claims are directed to fullerene molecules that are characterized in that they contain at least one free thermal neutron trapped within their cage-like structure. The Office contends that the claims are indefinite because the claims are not directed to a use for the fullerene. The applicants submit the Office's position makes no sense. While the rejected claims were at one time been directed to a proposed use of the fullerenes, the claims were amended to recouch that "use" in terms of a functional capability of the fullerene. As rewritten, the applicants submit a person skilled in the art reading the claims would know that they are directed to a fullerene in which the fullerene and/or trapped neutron are further defined in terms of a property or a suitability or capability.

For example, claim 4 is now directed to the embodiment in which the trapped neutron is defined as being in an accelerated state characterized by higher energy levels and claim 5 is directed to the embodiment in which the fullerene possesses an electrical charge. Claim 8 is directed to the embodiment in which the neutrons are capable of being released as a uniform beam, and claim 11 is directed to the embodiment in which the fullerene possesses the ability to release the trapped neutron at a remote location. Thus, it is clear from the plain language of the claims that the claims are not directed to an indefinite use but would be readily understood by one skilled in the art to be directed to a fullerene in which the trapped neutron is further defined by a capability, for example, to enter into defined nuclear action or result.

The Commissioner is authorized to charge any additional fee required by this paper (including the fee for any additional extension of time) or to credit any overpayment to Deposit Account No. 20-0809.

Respectfully submitted,

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Claims Appendix

1. A fullerene molecule having one or more free thermal neutrons trapped within the cage-like structure of said fullerene molecule.

2. The fullerene molecule of claim 1 wherein said fullerene molecule contains greater than about 30 carbon atoms.

3. The fullerene molecule of claim 2 wherein said fullerene molecule contains about 60 to 70 carbon atoms.

4. The fullerene molecule of claim 1 wherein said neutrons are accelerated to elevated energy levels.

5. The fullerene molecule of claim 4 wherein said neutron-containing fullerene is provided with an electrical charge.

6. The fullerene molecule of claim 4 wherein said neutrons are capable of creating a uniform beam of free thermal neutrons at a uniform energy.

7. The fullerene molecule of claim 1 wherein said free thermal neutrons are useful as an irradiation target for bombardment by other particles.

8. The fullerene molecule of claim 1 wherein said neutrons are capable of being released from said fullerene molecule as a uniform beam of free thermal neutrons at a uniform energy.

9. (Canceled)

10. The fullerene molecule of claim 8 wherein said neutrons are capable of being released from said fullerene molecule by impinging a beam of neutron-containing fullerenes on a metal foil.

11. The fullerene molecule of claim 8 wherein said neutrons are capable of being released from said fullerene molecule at a location removed from a source of said neutrons.

12. The fullerene molecule of claim 1 wherein said neutrons are capable of decaying into protons.

13. The fullerene molecule of claim 12 wherein said neutrons upon decay emit beta radiation and anti-neutrinos.

14. The fullerene molecule of claim 1 wherein said neutrons are capable of transforming into anti-neutrons via neutron/anti-neutron oscillation.

15. (Canceled)

16. The fullerene molecule of claim 14 wherein said anti-neutrons are capable of decaying into anti-protons.

17. The fullerene molecule of claim 16 wherein said anti-neutrons upon decay emit positrons and neutrinos.

18. The fullerene molecule of claim 1 wherein said neutrons are capable of combining with protons to form deuterium, tritium or a mixture thereof.

19. A C_{70} fullerene molecule having one or more free thermal neutrons trapped within said fullerene molecule, wherein said neutrons are capable of being released from said fullerene molecule at a location removed from a source of said neutrons by disassembling the fullerene molecule using a laser, an electric field, magnetic field, non-coherent electromagnetic radiation, particle bombardment, pressurization, mechanical force, heat, chemical reaction, electric current, or any combination thereof; or by impinging a beam of neutron-containing fullerene molecules on a metal foil.

20. (Canceled)

21. (Canceled)

22. (Canceled)

23. (Canceled)

24. (Canceled)

25. (Canceled)

26. (Canceled)

27. (Canceled)

28. (Canceled)

29. The fullerene molecule of claim 1 wherein the molecule is characterized in that it is a beta particle emitter, the beta particle emitter having a half life of about 10 minutes.

30. (Withdrawn)

31. (Withdrawn)

32. (Withdrawn)

33. The fullerene molecule of claim 3 wherein said fullerene contains about 70 carbon atoms.

34. The fullerene molecule of claim 1 wherein said one or more thermal neutrons are trapped within said fullerene molecule by a method which comprises irradiating said fullerene molecule in a nuclear reactor under a thermal neutron flux at a steady-state thermal power of about 10 to 500 kilowatts for about 5 to 15 minutes.